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Research Article

IFFERENTIAL TRANSFORMER SENSORS WITH SIMPLE STRUCTURE OF MAGNETIC CIRCUITS METHODS FOR INCREASING THE DISTRIBUTION LINEARITY OF MAGNETIC CURRENTS

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ABSTRACT

In the article differential transformer sensors measuring shifts the magnetic capacitance of the air gap between two long ferromagnetic cores, which allows the linear distribution of magnetic currents in ordinary structural scattered parameter differential magnetic circuits along the length of the chain, the expressions of the change of the magnetic circuit length of the compare values of the magnetic driving forces located longitudinal. Based on the analysis of differential magnetic chains with the proposed simple structure according to these analytical expressions, it was determined that the construction of a magnetic chain is technologically relatively simple and does not require an excess of non-ferrous metal (copper) due to the fact that the air gap between two long ferromagnetic cores changes the compare value of the magnetic.

KEYWORDS

Differential transformer sensor, differential magnetic chain; ordinary structural magnetic chain; scattered parameter chains; magnetic conducting force; magnetic resistance; magnetic capacitance, longitudinal and transverse Spurs, magnetic flux; magnetic voltage; linear distribution.

INTRODUCTION

Differential transformer sensors measuring shifts(DTS) are magnetic chains belonging to a series of scattered parametric chains, whose scattered magnetic parameters include long ferromagnetic rods corresponding to the length (angle) unit of the magnetic chain, or ring-shaped ferromagnetic cores with magnetic resistances Z_µcx,[1⁄(H·m)]), the air gap between them magnetic capacitance (C_µcx,[H·m^(-1)]), longitudinal and transverse scattered locusts include the comparative values of their mugs (f_rx,[A·m^(-1)]) and (f_gx,[A]) in the corresponding sequence [1.2].

According to the law of distribution of magnetic currents in the working part of chains in electromagnetic sensors with scattered parameter magnetic chains, magnetic chains are mainly divided into the following two categories [3,4]: 1) magnetic circuits with a simple distribution structure (just like the law of transmission of two-wire electrical energy and distribution of current and voltages along the length of the line in telegraph lines; 2) special structural magnetic chains with the same way of joining magnetic currents along the magnetic chain.

Due to the effect of magnetic resistances of these sterjens on the distribution of magnetic currents in electromagnetic sensors, including DTDS, which have long ferromagnetic sterjens that make up scattered parametric magnetic chains, they are distributed nonlinear throughout the measurement range [5]. This situation causes the static characteristics of DTS to appear non-existent, and their sensitivity to be variable across the measurement range, as well as a decrease in accuracy. In this article, we will consider the issue of developing methods that ensure that the parameters and working magnetic currents are linear, the law of distribution of currents of differential magnetic chains (DMCH)distributed according to a simple structure along the length of the chain (fig.1).

As you know [6], for the study of electromagnetic processes occurring in scattered parameter chains, it will be necessary to determine the patterns of change of the magnitudes that characterize these chains (in particular, for magnetic chains, the magnetic flux Q_µx and the magnetic voltage U_µx)along the length of the chain. In doing so, the classical method is often used, which is based on constructing and solving differential equations based on Kirchhoff's laws, for scattered parameter chains under study [7.8].

In order to somewhat simplify the calculations, we introduce the following restrictions, which are generally accepted in the theoretical study of this category of chains [3]: 1) the magnetic chain is linear, that is, the chain ferromagnetic material works in a rectilinear part of the main magnetization curve; 2) we do not take into account the scattered magnetic currents in the calculations; 3) we also do not take into account the longitudinal dimensions of the mules placed in the aggregate. Although these restrictions do not significantly affect the accuracy of calculations, but greatly facilitate the analysis of chains.

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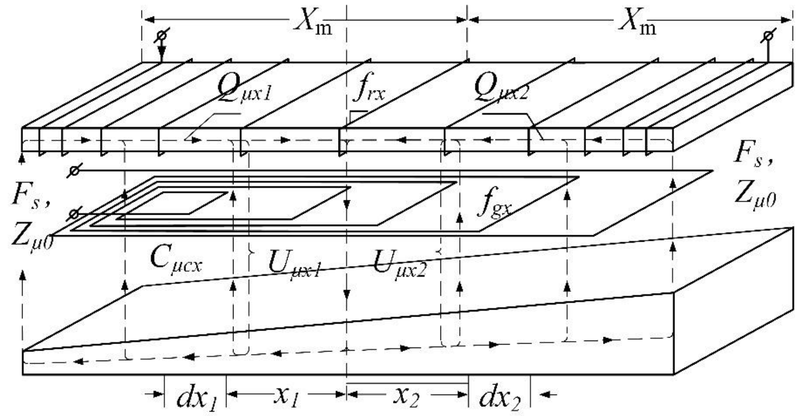

Figure 1. Magnetic currents are the most complex branch of a scattered parametric magnetic circuit with a simple distribution structure

Since at DMCH its left and right half parts are symmetrical with respect to the Middle cross section of the chain, it will be sufficient to carry out the analysis for one (for example, the left) half of it [4,9].

For the dx_1 length elemental part of the magnetic circuit shown in figure 1, we construct the following differential equations based on Kirxgof's laws (Figure 2):

$$Q_{\mu x1}+dQ_{\mu x1}-U_{\mu x1}C_{\mu cx}dx_1+f_{gx1}C_{\mu cx}dx_1-Q_{\mu x1}=0 \text{ ёки}$$

$$Q'_{\mu x1}=U_{\mu x1}C_{\mu cx}-f_{gx1}C_{\mu cx}, \qquad (1)$$

$$-U_{\mu x1}-dU_{\mu x1}+Z_{\mu cx}Q_{\mu x1}dx_1+U_{\mu x1}+Z_{\mu cx}Q_{\mu x1}dx_1=f_{rx1}dx_1 \text{ ёки}$$

$$U'_{\mu x1}=2Z_{\mu cx}Q_{\mu x1}-f_{rx}. \qquad (2)$$

From equation (1) we find the magnetic voltage $U_{\mu x1}$ and from (2) the magnetic flux $Q_{\mu x1}$ as follows:

$$U_{\mu x1}=Q'_{\mu x1}/C_{\mu cx}+f_{gx}. \quad (3) \qquad Q_{\mu x1}=U'_{\mu x1}/2Z_{\mu cx}+f_{gx}/2Z_{\mu cx}. \quad (4)$$

Equation (1) by taking a derivative by two x coordinates and placing (2) and (3) in the resulting equation, we form the following differential equation with a second order non-homogeneous variable coefficient relative to the magnetic flux [3,4]:

$$Q''_{\mu x1}-\frac{C'_{\mu cx}}{C_{\mu cx}}Q'_{\mu x1}-2Z_{\mu cx}C_{\mu cx}Q_{\mu x1}=-C_{\mu cx}(f_{rx}+f'_{gx}). \qquad (5)$$

Now, taking the derivative from (2) and placing (1) and (4) in the result, we form the following differential equation with a second order non-homogeneous variable coefficient relative to the magnetic voltage:

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$$U''_{\mu x1} - \frac{Z'_{\mu cx}}{Z_{\mu cx}} U'_{\mu x1} - 2Z_{\mu cx} C_{\mu cx} U_{\mu x1} = \frac{Z'_{\mu cx}}{Z_{\mu cx}} f_{rx} - 2Z_{\mu cx} C_{\mu cx} f_{rx} - f'_{rx}. \qquad (6)$$

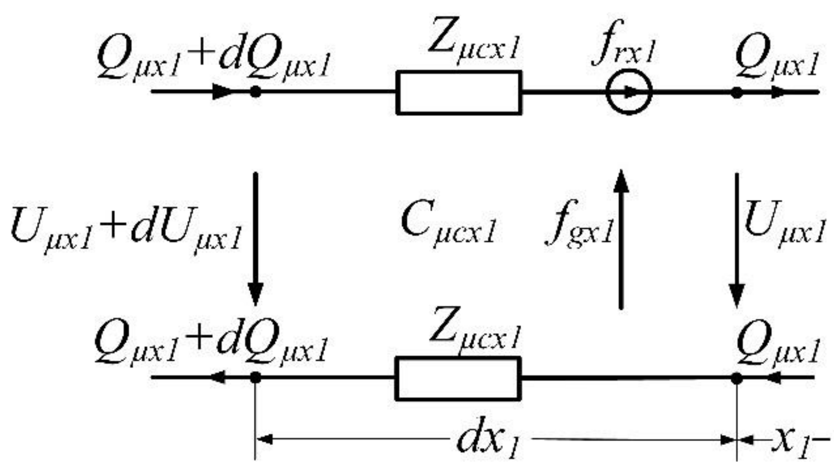

Figure 2. The most complex fragment of a magnetic chain with a simple structural scattered parameter is the exchange scheme of an elementary part of the length dx_1

The analysis of the resulting differential equations (5) and (6) shows that the law of change of magnetic flux and magnetic voltage along the length of the chain in a magnetic chain with scattered parameters depends on the law of change of its scattered parameters.

In order for the magnetic currents of DMCH to be linear along the length of the magnetic chain, that is, distributed according to the law $Q_{\mu x} = kx + b$, the following condition will need to be met [10]:

$$Q''_{\mu x} = 0. \qquad (7)$$

Therefore, in order to achieve that the magnetic flux is evenly distributed along the length of the magnetic chain, it is necessary to determine the law of change of the parameters of the magnetic chain on the basis of condition (7).

1. *We determine the law of change of $C_{\mu \pi x} = var$, which allows to ensure the linear distribution of magnetic flux along the chain length at a simple structural scattered parametric DMCH with $Z_{\mu cx} = Z_{\mu c} = const$; $f_{rx} = 0$; $f_{gx} = 0$.* For this case, taking into account the condition (7) (5) the differential equation comes to the following view:

$$Q''_{\mu x1} = \left(U_{\mu x1} C_{\mu cx1}\right)' = 0. \qquad (8)$$

(8) by integrating the differential equation, we form the following equation:

$$U_{\mu x1} C_{\mu cx1} = A_1. \qquad (9)$$

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For the observed magnetic chain, the equations (1) and (2) are written in the following form:

$$Q'_{\mu x1} = U_{\mu x1} C_{\mu cx1}, \quad (10) \qquad U'_{\mu x1} = 2Z_{\mu c} Q_{\mu x1}. \quad (11)$$

Equation (11) we form the following differential equation by taking a derivative by two and placing (9) and (10) in the resulting equation:

$$U''_{\mu x1} = 2Z_{\mu c}\, A_1. \quad (12)$$

If the equation (12) is integrable twice in a row, then the following equation is formed:

$$U_{\mu x1} = Z_{\mu c} A_1 x_1^2 + A_2 x_1 + A_3. \quad (13)$$

From equation (9) we find $C_{\mu cx}$ and by putting (13) in the result we form the following equation:

$$C_{\mu cx1} = A_1 / \left(Z_{\mu c} A_1 x_1^2 + A_2 x_1 + A_3\right). \quad (14)$$

When finding the values of the Integrative constants A_1, A_2 and A_3, we use the following boundary conditions that are appropriate for the magnetic chain under study:

$$U_{\mu x1=0} = U_{\mu 0} = A_3; \;\; C_{\mu cx1=0} = C_{\mu c0} = A_1/A_3; \;\; Q_{\mu x1=0} = A_2. \quad (15)$$

Putting the found values of A_1, A_2 and A_3 (13) and (14), we form:

$$U_{\mu x1} = U_{\mu 0}\left(1 + Z_{\mu c} C_{\mu c0} x_1^2\right). \; (16) \qquad C_{\mu cx1} = C_{\mu c0} / \left(1 + Z_{\mu c} C_{\mu c0} x_1^2\right). \; (17)$$

It is worth mentioning that the value of $C_{\mu п0}$ is selected based on the properties of the magnetic circuit and is the parameter given for the chain.

The value of the magnetic flux (2.13) is found based on the equation:

$$Q_{\mu x1} = U'_{\mu x1} / 2Z_{\mu c} = U_{\mu 0} C_{\mu c0} x_1. \quad (18)$$

To find the value $U_{\mu 0}$, we use the following equation for the berk contour of the magnetic circuit under study, formulated on the basis of Kirchgof's second law:

$$F_s = Q_{\mu x1 = X_m} Z_{\mu 0} + 2Z_{\mu п} \int_0^{X_m} Q_{\mu x1} dx_1 + U_{\mu x1=0}, \quad (19)$$

where F_s, $[A]$, $Z_{\mu 0}$, $[H^{-1}]$ – the left side of the magnetic chain is placed in a cumulative view at the edge of the trigger chulgin MDF and its internal magnetic resistance.

By placing the corresponding values of $Q_{\mu x1}$and $U_{\mu x1}$ in equation (19), we form the following expression for $U_{\mu 0}$:

$$U_{\mu 0} = F_s / \Delta. \quad (20)$$

where $\Delta = 1 + Z_{\mu 0} C_{\mu c0} X_m + Z_{\mu c} C_{\mu c0} X_m^2, [-]$.

Taking into account (20), we form the following final expressions of magnetic flux and magnetic voltage in a magnetic circuit with a diffuse parameter:

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$Q_{\mu x1} = F_s\, C_{\mu c0} x_1/\Delta.$ (21) $U_{\mu x1} = F_s\big(1 + Z_{\mu c} C_{\mu c0} x_1^2\big)/\Delta.$ (22)

Also for the second (right) half of the DMCH in figure 1, the corresponding size and parameters are generated in the same sequence as above. We limit ourselves to bringing their final expressions below:

$C_{\mu cx2} = C_{\mu c0}/\big(1 + Z_{\mu c} C_{\mu c0} x_2^2\big),$ (23) $Q_{\mu x2} = F_s\, C_{\mu c0} x_2/\Delta,$ (24)

$$U_{\mu x2} = F_s\big(1 + Z_{\mu c} C_{\mu c0} x_2^2\big)/\Delta. \quad (25)$$

From the analysis of expressions (16) and (17) and (23) and (25), they can be written as follows:

$C_{\mu cx} = C_{\mu c0}/\big(1 + Z_{\mu c} C_{\mu c0} x^2\big).$ (26) $U_{\mu x} = F_s\big(1 + Z_{\mu c} C_{\mu c0} x^2\big)/\Delta,$ (27)

where x is the coordinate starting from the middle cross section of the chain.

As can be seen from the expression (26), the pogon value of the magnetic capacitance of the working air gap is required to be hyperbolic decreasing depending on both edges of it, starting from the Middle cross section of the DMCH, in order for the working magnetic currents in the scattered parametric DMCH to change with linear legitimacy (21) and (24).

(26) we change the expression as follows:

$$C_{\mu c}^{*} = 1/\left[1 + \tfrac{1}{2}(\beta_0 x^{*})^2\right]. \quad (28)$$

where $C_{\mu cx}^{*} = C_{\mu cx}/C_{\mu c0}$, $[-]$; $x^{*} = x/X_m$, $[-]$ - magnetic capacitance pogon value respectively relative values of the coordinate$\beta_0 = \gamma X_m, [-]]$ - the initial value of the extinction coefficient along the magnetic chain of the magnetic flux; $\gamma = \sqrt{2 Z_{\mu c} C_{\mu c0}}, [m^{-1}]$- the initial value of the propagation coefficient of the magnetic flux along the magnetic chain.

As can be seen from the above, the β_0 coefficient scattered parametric magnetic circuit fully describes changes in magnetic properties and structural dimensions. Therefore, when analyzing the function $C_{\mu c}^{*} = f(x^{*})$, it will be enough to study its change in different values of β_0 (fig. 3).

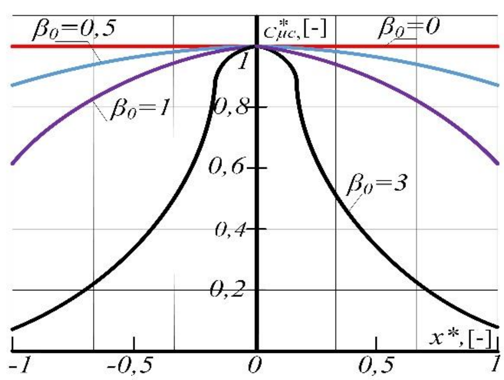

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Figure 3. C_μc^*=f(x^*)graphs of the magnetic flux of a function built for different initial values of the extinction coefficient along the magnetic circuit

The analysis of the function (28) and its graphs constructed in fig. 3 shows that the working air gap magnetic capacitance required to implement a linear distribution of the working magnetic fluxes along the length of the magnetic circuit in a simple structured DMCH is the rate of change of the Pogon value along the length of the circuit. the extinction coefficient increases with the initial value β_0.

Linear distribution of working magnetic currents along the length of the magnetic circuit working air range is shown in figure 4 of the DTD construction, which is achieved on the basis of the change in the magnetic capacitance pogon value along the length of the chain (26) by law, and the novelty of which is patented by the invention [11].

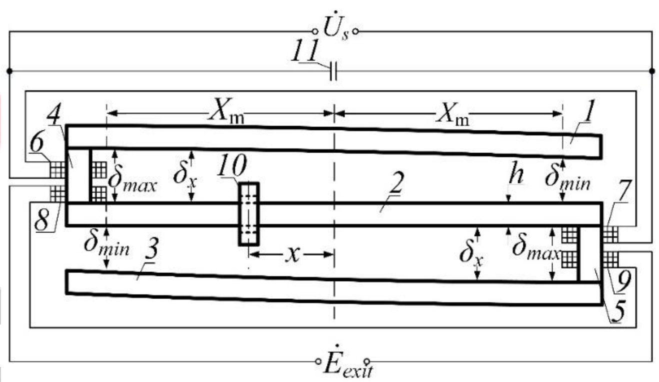

Figure 4. DTDs measuring displacements with simple structure of magnetic chains and excitation coil tuned to resonance: 1-3 – long ferromagnetic rods; 4.5 – ferromagnetic connectors; 6.7 – sections of the excitation coil; 8, 9 – sections of the measuring coil 10 – moving element; 11 - condenser

2. *$C_{\mu cx} = C_{\mu c} = const$; $f_{rx} = 0$; $f_{gx} = 0$ we determine the law of change of $Z_{\mu cx} = var$, which allows to ensure the linear distribution of magnetic flux along the chain length at a simple structural scattered parameter DMC.* For this case, taking into account the condition (7) (5) the differential equation comes to the following view:

$$Q''_{\mu x} = 2Z_{\mu cx}C_{\mu c}Q_{\mu x} = 0. \qquad (29)$$

(29) equation analysis shows that in the magnetic circuit(7) in this investigated structure, the condition is fulfilled only when $Z_{\mu cx} = 0$, that is, with the choice of the function $Z_{\mu cx} = f(x)$, it will not be possible to ensure the linear distribution of the magnetic flux along the length of the chain.

3. *$Z_{\mu cx} = Z_{\mu c} = const$; $C_{\mu cx} = C_{\mu c} = const$; we define the law of change of $f_{rx} = var$, which allows to ensure the linear distribution of the magnetic flux along the chain length in the left half of the differential magnetic circuit with*

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a simple structural scattering parameter $f_{gx} = 0$. For this case, taking into account the condition (7), the differential equation (5) takes the following form:

$$Q''_{\mu x1} = 2Z_{\mu c}C_{\mu c}Q_{\mu x1} - C_{\mu c}f_{rx1} = U'_{\mu x1}C_{\mu c} = 0. \qquad (30)$$

By combining the last differential equation, we get the following function:

$$U_{\mu x1} = A_1. \qquad (31)$$

By placing (31) in (1) (taking into account that $f_{gx} = 0$), integrating the resulting differential equation, we form the following expression for the magnetic flux:

$$Q_{\mu x1} = A_1 C_{\mu c} x_1 + A_2. \qquad (32)$$

(2) ва (30) га кўра $U'_{\mu x1} = 2Z_{\mu c}Q_{\mu x1} - f_{rx1} = 0.$ (33)

From this: $f_{rx1} = 2Z_{\mu c}Q_{\mu x1} = 2Z_{\mu c}(A_1 C_{\mu c} x_1 + A_2).$ (34)

In finding the values of the Integrative constants A_1, and A_2, we use the following boundary conditions that are appropriate for the magnetic chain under study:

$$U_{\mu x1=0} = U_{\mu 0} = A_1; \qquad Q_{\mu x1=0} = A_2 = 0. \qquad (35)$$

To find $U_{\mu 0}$, we use the following algebraic equation for the berk contour of the magnetic circuit under study, formulated on the basis of Kirchgof's second law:

$$F_s + F_{rx1} = Q_{\mu x1=0}Z_{\mu 0} + 2Z_{\mu c}\int_0^{X_m} Q_{\mu x1}dx + U_{\mu x1=0}, \qquad (36)$$

where $F_{rx} = I_s w_{rs}, [A]$, I_s, w_{rs} is the number of excitation chulgami MDF, toki and wraps located in the longitudinal scatter.

Finding the value $U_{\mu 0}$ from (36), we put the A_1 identified through it into (31), (32) and (34) to form the following final expressions:

$$Q_{\mu x1} = [(F_s + F_{rx1})/\Delta]C_{\mu c}x_1, \quad (37) \qquad U_{\mu x1} = (F_s + F_{rx1})/\Delta, \quad (38)$$

$$f_{rx1} = [2Z_{\mu c}\,(F_s + F_{rx1})/\Delta]C_{\mu c}x_1. \qquad (39)$$

Also for the second (right) half of the DMCH in figure 1, the corresponding size and parameters are generated in the same sequence as above. We limit ourselves to bringing their final expressions below:

$$Q_{\mu x2} = [(F_s + F_{rx2})/\Delta]C_{\mu c}x_2, \quad (40) \qquad U_{\mu x2} = (F_s + F_{rx2})/\Delta, \quad (41)$$

$$f_{rx2} = [2Z_{\mu c}\,(F_s + F_{rx2})/\Delta]C_{\mu c}x_2. \qquad (42)$$

If it is taken into account that $x_1 = x$ and $x_2 = -x$ (figure 1), then expressions (39) and (42) for a simple structural DMJ can be written by the following single expression:

$$f_{rx} = [2Z_{\mu c}\,(F_s + F_{rx})/\Delta]C_{\mu c}|x|. \qquad (43)$$

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The analysis of the derived expressions (37)-(39) and (40)-(42) shows that the working magnetic currents of a long ferromagnetic rod in a distributed parameter DMCH with a simple structure vary linearly according to (37) and (40) in the section, the pogon value of the longitudinally scattered chulgam MDF is required to increase linearly according to the function (43) starting from the middle section of the DMCH towards its two edges.

It should be mentioned that even when $F_s = 0$, the linearity of the magnetic currents in the studied DMCH is preserved.

(43) we change the expression as follows:

$$f_{rx} = [\beta^2 \, (F_s + F_{rx})/\Delta^*]|x|. \qquad (44)$$

where $\Delta^* = X_m(1 + \beta^2/2)$; $\beta = \gamma X_m = \sqrt{2Z_{\mu c}C_{\mu c}}X_m$. In most cases $Z_{\mu 0} \ll 1/(C_{\mu c}X_m)$ it would be possible to accept that $Z_{\mu 0}C_{\mu c}X_m \approx 0$, because the condition is appropriate [12].

we also convert f_{rx} to the following relative unit:

$$f_{rx}^* = \frac{f_{rx}}{f_{rxmax}} = \left(\frac{\beta}{\beta_{max}}\right)^2 \cdot \frac{\Delta^*(\beta_{max})}{\Delta^*(\beta)}|x^*|, \qquad (45)$$

where $\Delta^*(\beta) = X_m(1 + 0{,}5\beta^2)$; $\Delta^*(\beta_{max}) = X_m(1 + 0{,}5\beta_{max}^2)$, in the scattered parametric magnetic chains of DTDs, generally, $\beta_{max} \leq 3$ conditions are met [3]. We derive the value of f_{rx} from the function x^* in order to determine the magnitude of the change in the length of the magnetic chain (45):

$$(f_{rx}^*)' = \left(\frac{\beta}{\beta_{max}}\right)^2 \cdot \frac{\Delta^*(\beta_{max})}{\Delta^*(\beta)}. \qquad (46)$$

analysis of graphs of the function $f_{rx}^* = f(|x^*|)$ built on the basis of (45) for different values of β shows that (figure 5), a worker in a scattered parametric DMCH

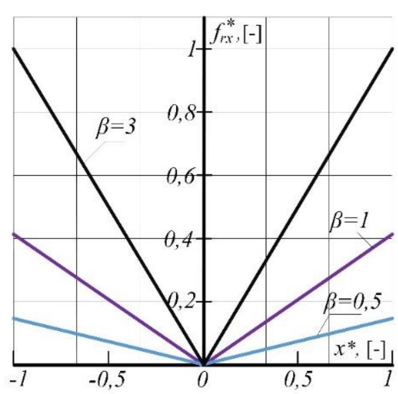

Figure 5. f_rx^*=f(|x^* |) graphs of the magnetic flux of a function built for different values of the coefficient of fading along the magnetic circuit

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the rate of change of the longitudinal scattered winding chulgam MDF pogon value along the chain length to the long ferromagnetic sterjen needed to carry out the linear distribution of magnetic currents along the length of the magnetic circuit increases the magnetic flux with a constant magnitude with an increase in the value of the extinction coefficient β along the magnetic chain.

The linear distribution of the working magnetic currents along the length of the magnetic chain in one of the long ferromagnetic rods, and the pogon value of the DMJ changes according to the law (43), is presented in fig. 6.[13].

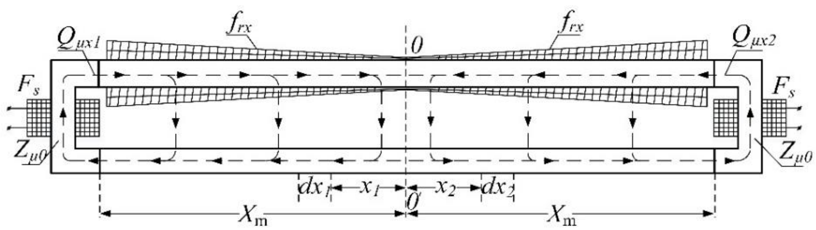

Figure 6. Simple structural DMCH with Z_μc const; C_μc=const; f_gx=0 and f_rx=var

4. *$Z_{\mu cx} = Z_{\mu c} = const;\ C_{\mu cx} = C_{\mu c} = const;\ f_{rx} = 0$ we define the law of change of $f_{gx} = var$, which allows us to ensure the linear distribution of magnetic flux along the chain length at a simple structural diffuse parametric DMCH with $f_{rx} = 0$.* For this case, taking into account the condition (7) (5) the differential equation comes to the following view:

$$Q''_{\mu x1} = C_{\mu c}\left(U_{\mu x1} - f_{gx1}\right)' = 0.$$

or $$\left(U_{\mu x1} - f_{gx1}\right)' = 0. \qquad (47)$$

(47) by integrating the differential equation, we form the following expression:

$$U_{\mu x1} - f_{gx1} = A_1. \qquad (48)$$

Taking the derivative from the equation (taking into account that $f_{rx} = 0$) and placing (48) on the result, we form the following differential equation:

$$U''_{\mu x1} = 2Z_{\mu c}C_{\mu c}A_1. \qquad (49)$$

By integrating (50) twice, we form the following function:

$$U_{\mu x} = Z_{\mu c}C_{\mu c}A_1x_1^2 + A_2x_1 + A_3. \qquad (50)$$

Magnetic flux: $Q_{\mu x1} = U'_{\mu x1}/2Z_{\mu c} = C_{\mu c}A_1x_1 + A_2/2Z_{\mu c}$. (51)

The pogon value (48) of the excitation chulgam MDF, where the transverse and winding are arranged scattered, is found from the equation and is equal to:

$$f_{gx1} = Z_{\mu c}C_{\mu c}A_1x_1^2 + A_2x_1 + A_3 - A_1. \qquad (52)$$

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When finding the values of the Integrative constants A_1, A_2 and A_3, we use the following boundary conditions that are appropriate for the magnetic chain under study:

$$Q_{\mu x1=0} = A_2/2Z_{\mu c} = 0; \quad U_{\mu x1=0} - f_{g0} = A_1; U_{\mu x1=0} = U_{\mu 0} = A_3. \qquad (53)$$

the value of f_{g0} is selected based on the properties of the magnetic circuit and is the given parameter for the chain. In finding the value of $U_{\mu 0}$, however, we use the following algebraic equation for the berk contour of the magnetic chain under study, as carried out above, formulated on the basis of Kirchgof's second law:

$$F_s = Q_{\mu x1=X_m} Z_{\mu 0} + 2Z_{\mu c} \int_0^{X_m} Q_{\mu x1} dx_1 + U_{\mu x1=0}. \qquad (54)$$

By placing the values of $Q_{\mu x1}$ and $U_{\mu x1}$ in $x_1 = 0$ in equation (54), we find the following value of $U_{\mu 0}$ from it:

$$U_{\mu 0} = (F_s - f_{g0})/\Delta + f_{g0}. \qquad (55)$$

Putting (55) into equations (53), we find the values of the Integrative constants A_1, A_2 and $A_3$from them, and putting them in (50)-(52), we form the following final expressions of the sought quantities:

$$U_{\mu x1} = [(F_s - f_{g0})/\Delta](1 + Z_{\mu c} C_{\mu c} x_1^2) + f_{g0}, \qquad (56)$$

$$Q_{\mu x1} = [C_{\mu c}(F_s - f_{g0})/\Delta] x_1, (57) \qquad f_{gx} = [Z_{\mu c} C_{\mu c}(F_s - f_{g0})/\Delta] x_1^2 + f_{g0}. (58)$$

For the right half of the differential magnetic chain under study, the above - derived expressions are generated, and they differ from (56) - (58) by the writing of x_1 instead of x_2.

If it is taken into account that $x_1 = x$ and $x_2 = -x$ (figure 1), then for a simple structural DMCH (58) the function can be written as:

$$f_{gx} = [Z_{\mu c} C_{\mu c}(F_s - f_{g0})/\Delta] x_1^2 + f_{g0}. \qquad (59)$$

(56)-(59) function analysis shows that $Z_{\mu cx} = Z_{\mu c} = const$; $C_{\mu cx} = C_{\mu c} = const$; $f_{rx} = 0$ and $f_{gx} = var$ in simple structural scattered parametric DMCHs, the pogon value of the cross-dispersed arranged trigger chulgam MDF is required to increase by quadratic law depending on both its edges, starting from the mid-section of the DMCH according to (59) are you looking for.

(59) we write the expression $f_{gx} = 0$ for the case in the following form:

$$f_{gx}^* = \frac{f_{gx}}{f_{gxmax}} = \left(\frac{\beta}{\beta_{max}}\right)^2 \cdot \frac{\Delta^*(\beta_{max})}{\Delta^*(\beta)} (x^*)^2. \qquad (60)$$

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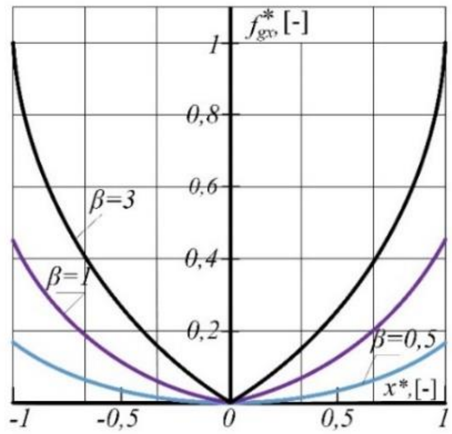

Figure 2.6. f_gx^*=f(x^*) graphs of the magnetic flux of the function built for different values of the coefficient of fading along the magnetic circuit

The analysis of the function (60) and its graphs constructed at different values of b shows that (fig. 6) a cross-dispersed wound winding between two mutually parallel long ferromagnetic rods is needed to implement a linear distribution of the working magnetic fluxes in the DMCH with a distributed parameter along the length of the magnetic circuit. The rate of change of the value of the MDF pogon along the length of the circuit increases with the increase in the value of the extinction coefficient b of the magnetic flux along the magnetic circuit.

Thus, in this article, displacement-measuring DTDs in DMCHs with simple structural scattered parameters, which enable the linear distribution of magnetic currents along the length of the chain, are used to determine the magnetic capacitance of the air gap between two long ferromagnetic cores, the magnetic capacitance of the air gap between two long ferromagnetic cores, and the values of the MDFs comparative values of the excitation coils located longitudinally and transversely scattered along the chain. Analytical expressions of changes along the length of magnetic chains were derived.

The analysis of DMCHs with a simple structure theoretically researched above shows that the construction of a magnetic circuit in which the value of the magnetic current can be linearly distributed along the length of the chain due to the change of the pogon value of the magnetic capacitance of the air gap between two long ferromagnetic cores along the length of the chain is technologically relatively simple and redundant. does not require non-ferrous metal (copper).

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